CHAPTER 3.0 - NOISE AND VIBRATION

3.1 OVERVIEW

As discussed previously in Chapter 2, SEA prepared a detailed evaluation of the potential noise impacts associated with the proposed project in the EIS. The Board has no guidelines or regulations regarding an evaluation of vibration related to rail activity. In preparing the Draft Scope of Study (Scope) for the EIS, SEA did not anticipate studying potential vibration effects in its environmental review. However, during the scoping process, SEA received a number of comments expressing concern for potential adverse impacts from increases in vibration due to more, longer, and heavier coal trains operating over the existing rail line. In response to these comments, SEA, in the Final Scope, revised the Scope of the EIS to include evaluation of the potential effects of vibration.

SEA then considered both noise and vibration separately for the EIS. This evaluation included wayside noise, locomotive horn noise, air-borne vibration, and ground-borne vibration. SEA determined, as discussed in the Draft and Final EIS and summarized below, that increases in noise could cause significant adverse impacts, while increases in vibration would not result in significant impacts. SEA recommended appropriate mitigation to address both noise and vibration.

In its comments on the Draft EIS and again on judicial review in the Mid States case, the City of Rochester argued that, as part of its analysis, SEA should have considered the synergies between noise and vibration. According to Rochester, "*households experiencing both noise and vibration perceive the effect of the noise to be approximately twice the measured value of the noise*" alone.[1] Although the court was satisfied that SEA had "*included analysis for noise and*

[1] See 345 F. 3d at 537.

vibration effects separately," it could "*find no evidence that* [*SEA*] *considered the synergies between the two in its response to comments*" from the Rochester parties.[2] The court remanded this issue for SEA to "*fulfill its duty*"[3] to respond to all comments.

For this Draft SEIS, in response to the court's direction, SEA has conducted additional analysis investigating the potential impacts to noise sensitive receptors related to noise and vibration synergies. Although the arguments made on this issue relate only to the City of Rochester, SEA's supplemental analysis has encompassed the entire project (including noise sensitive receptors along the proposed new rail line and the existing rail line proposed for rehabilitation). The following sections summarize SEA's previous analysis presented in the EIS, SEA's additional investigation of noise and vibration synergies, the potential impacts resulting from these synergies as a result of the proposed project, and the mitigation, if any, SEA deems warranted to address these impacts.

3.2 SUMMARY OF SEA'S PREVIOUS ANALYSIS

As discussed here and in Chapter 2 of this Draft SEIS, SEA conducted an extensive evaluation of noise and vibration for the EIS. As the court recognized in Mid States,[4] during the EIS process, SEA measured noise and vibration individually. SEA's activities included:

---

[2] Id.

[3] Id.

[4] 345 F. 3d at 537.

- field measurement of actual train noise, both wayside and locomotive horn noise.
- development of a model to predict future noise levels at various distances from the proposed and existing rail lines.
- field measurement of actual train-induced ground vibration along the existing rail line.
- calculation of potential ground vibration levels due to operation of the proposed project.

SEA determined that thousands of noise sensitive receptors could be exposed to adverse levels of noise from passing trains and locomotive horn soundings.[5] And after taking actual measurements of vibration from passing trains from within the Charlton North Building and at other locations along the existing rail line, including residential areas in Rochester, SEA determined in the Final EIS that, while likely to cause disturbance and inconvenience, vibration from the project would not result in significant impacts.[6] SEA's measurements indicated a current vibration, or peak particle velocity, of 0.01 inches/second (in/s), or approximately 0.254 millimeters per second (mm/s), from passage of existing trains. Based on these vibration levels, SEA projected project-related vibration of less than 0.04 in/s (1.02 mm/s) due to proposed operation of unit coal trains as a result of this project.[7] These levels of vibration are extremely

[5] Draft EIS, Chapter 3, Tables 3.2-5 to 3.2-20; 3.3-3 to 3.3-5; 3.3-13 to 3.3-16; 3.4-3; Chapter 4, Tables 4.1-9; 4.2-6; 4.3-5 to 4.3-19; 4.4-18 to 4.4-37; 4.5-7 to 4.5-18; 4.6-10 to 4.6-27; 4.9-3 to 4.9-8; 4.10-2; and 4.10-11.

[6] SEA's vibration measurements, as presented in the Final EIS, Appendix M, indicted only structures within 50 feet of the rail line would be susceptible to potential damage from vibration caused by passing trains. SEA did not identify any structures within 50 feet of the rail line.

[7] Final EIS, Appendix M, pages M-29 to M-30.

low and would be imperceptible to humans.[8] Even so, to minimize any potential effects that vibration could have, SEA recommended a number of mitigation measures to address increased noise and vibration, all of which the Board imposed in the 2002 Decision.[9]

On judicial review in Mid States, the court rejected all of petitioners' challenges to the Board's noise methodology except for the horn noise and noise/vibration synergies issues addressed in Chapters 2 and 3, respectively, of this Draft SEIS. As directed by the court, the following discusses SEA's further analysis of the issue of noise/vibration synergies.

3.3 SEA'S ADDITIONAL REVIEW

SEA began its further analysis, in response to the court's decision in Mid States, directing that the Board consider in more detail the City of Rochester's comments on the Draft EIS suggesting that a synergistic relationship exists between noise and vibration which allegedly results in noise being perceived as greater than measured when the receptor is simultaneously also exposed to vibration, by considering the articles Rochester had cited to support this position:

- Paulsen, R. and J. Kastka. 1995. *Journal of Sound and Vibration* (1995). 181(2), 295-314. Effects of Combined Noise and Vibration on Annoyance.

[8] Wiss, J. F. (1981). *Proceedings of the American Society of Civil Engineers, Journal of the Geotechnical Engineering Division*, Vol. 107, No. GT2, February, 1981. Construction Vibrations: State of the Art.

[9] See Appendix C, conditions 86-96, pages 30-32.

- Öhrström, E. 1997. *Journal of Sound and Vibration* (1997). 205(4), 555-560. Effects of Exposure to Railway Noise—A Comparison Between Areas With and Without Vibration.

Additionally, SEA conducted its own independent review of existing literature on noise and vibration to identify any synergies between noise and vibration, particularly any cumulative effects from simultaneous exposure to both. This review included an extensive literature search of the *Journal of Sound And Vibration*, *Journal of the Acoustical Society of America*, and others. SEA found numerous articles on noise, rail noise, vibration, and rail vibration. However, few of these articles dealt with the combined effects of exposure to noise and vibration, much less the combination of rail noise and rail vibration. SEA did find two articles, in addition to the two provided by Rochester, that address the combined effects of noise and vibration:

- Miwa, T. and Y. Yonekawa (1973). *Industrial Health*, 11, 177-184. Measurement and evaluation of environmental vibrations, part 2: interaction of sound and vibration, and
- Howarth, H.V.C., and M.J. Griffin. 1990. *Journal of Sound and Vibration* (1990) 143(3), 443-454. Subjective Response to Combined Noise and Vibration: Summation and Interaction Effects.

Table 3-1 below summarizes the conclusions of each of the four referenced articles. As explained there, one of the articles cited by Rochester (Öhrström 1997), does indicate that noise in combination with vibration is more annoying than noise alone.[10] Of the other articles, Paulsen

[10] Rochester's suggestion in its comments that "simultaneous noise and vibration causes households to perceive noise as double (10dB) its measured value" is incorrect. Rochester's own source states only that at a particular level of noise, exposure to simultaneous vibration levels greater than 2 mm/s increased the number of receptors categorized as rather annoyed and very annoyed by as much as 29 percent over receptors exposed to that

Table 3-1

Summary of Combined Noise and Vibration Articles

Article	Summary of Findings
Paulsen, R. and J. Kastka. 1995. Effects of Combined Noise and Vibration on Annoyance	Laboratory study investigating effects of vibration from tram, vibration from hammermill, noise from tram, noise from hammermill, and combination of tram and hammermill. **Vibration results:** under strong vibration, subjects perceived vibration; when exposed to strong noise and low vibration, noise was perceived but vibration was not. **Noise results:** perception of noise was not influenced by simultaneous vibration**. Overall results:** annoyance depends on levels of vibration and noise. When exposed to both, noise predominates, with vibration having slight influence.
Öhrström, E. 1997. Effects of Exposure to Railway Noise—A Comparison Between Areas With and Without Vibration	Study evaluating results of responses to postal questionnaire from citizen along selected railways in Sweden. **Results:** Railway noise is more annoying and disturbing when simultaneous vibration is experienced. Strong vibration (exceeding 2 mm/s) in areas increases the annoyance from noise over those areas with weak or no vibration (less than 1 mm/s).
Miwa, T. and Y. Yonekawa (1973). Measurement and evaluation of environmental vibrations, part 2: interaction of sound and vibration	Laboratory study using impulsive vibration and diesel pile driver noise as vibration and noise sources, respectively, to investigate influence of noise on perception of vibration. **Results:** Simultaneous noise reduced reaction to vibration.

level of noise alone. Vibration does not increase the level at which noise is perceived, but only increases the level of annoyance from the noise. By reducing the noise level 10dB or greater when vibration is present, the annoyance level can be reduced.

Table 3-1 Summary of Combined Noise and Vibration Articles	
Article	**Summary of Findings**
Howarth, H.V.C., and M.J. Griffin. Subjective Response to Combined Noise and Vibration: Summation and Interaction Effects	Laboratory study simulating rail-generated noise and vibration experienced by residents in homes near rail lines. Vibration levels ranged from 0.07 to 0.40 meters/s (m/s). **Results:** Subjects assessment of minor vibration was decreased at high noise levels, but increased under both high vibration and high noise levels. At high levels of vibration, annoyance was increased by presence of noise. Vibration was not found to have the same influence on noise.

and Kastka (1995) reported vibration having a slight influence on noise perception. Miwa and Yonekawa (1973) found noise to reduce reaction to simultaneous vibration. Howarth and Griffin (1990) reported that annoyance from vibration was increased by simultaneous noise but that simultaneous vibration was not found to increase the annoyance from noise.

The results of these studies indicates some synergistic effect between noise and vibration in certain circumstances. Specifically, the presence of vibration, at least at high levels, may increase the annoyance level or perception of noise. Additionally, at high levels of noise, the annoyance or perception of strong vibration may be increased. However, low levels of vibration seem to have no effect on perception of noise. In fact, at low levels, vibration may actually be masked by noise and not perceived by the subject, while having no effect on the subject's perception of the simultaneous noise.

Because the available literature appears to indicate there may be a synergistic relationship between noise and vibration where rail-generated vibration would exceed 2 mm/s, SEA investigated whether vibration levels from the proposed project would exceed 2 mm/s. SEA's evaluation is discussed below.

3.4 POTENTIAL PROJECT IMPACTS OF NOISE AND VIBRATION SYNERGIES

As discussed above, Öhrström (1997) reports an increase in annoyance from rail noise due to rail-induced vibration levels greater than 2 mm/s (0.078 in/s). This level, 2 mm/s, would be only slightly perceptible to humans.[11] However, it was the lowest level of vibration for which a corresponding increase in noise perception or annoyance was reported.[12]

As discussed previously, SEA obtained measurements of train-generated vibration for the Final EIS. SEA reported in the Final EIS that recorded vibration levels of 0.01 in/s were measured for current trains during train passing events.[13] SEA also projected that vibration due to heavier, longer trains would be 0.04 in/s or less.[14] SEA measured vibration in units of in/s while vibration in the articles reviewed is presented in mm/s. Table 3-2 provides a summary of various vibration levels, converting SEA's measured vibration from in/s to mm/s and literature vibration levels from mm/s to in/s for comparison.

[11] Wiss, J. F. (1981). *Proceedings of the American Society of Civil Engineers, Journal of the Geotechnical Engineering Division*, Vol. 107, No. GT2, February, 1981. Construction Vibrations: State of the Art.

[12] Howarth and Griffin (1990) looked at vibration levels as low as 0.07 m/s. This is equivalent to 70 mm/s.

[13] Final EIS, Chapter 4, page 4-12 and Appendix M, page M-29.

[14] Final EIS, Appendix M, pages M-27 to M-36.

Table 3-2
Comparison of Vibration Levels

Vibration levels - inches/second (in/s)	Vibration levels - millimeters/second (mm/s)
1.0 in/s	25.4 mm/s
0.1 in/s	2.54 mm/s
0.078 in/s*	2.0 mm/s*
0.04 in/s**	1.02 mm/s**
0.01 in/s***	0.254 mm/s***

* Level above which synergistic effects between noise and vibration are noted to occur.[15]

** Maximum projected level of potential vibration from proposed project.[16]

*** Measured, vibration from existing trains.

Table 3-2 shows that maximum vibration levels due to the proposed project would be approximately 1.02 mm/s (0.04 in/s) or less. This vibration level would be imperceptible to humans, however.[17] Additionally, Öhrström (1997) indicted that while vibration levels greater than 2 mm/s resulted in an increased level of annoyance from noise (synergistic effect), vibration levels of 1 mm/s or less (as would be the case for the proposed project) would have no affect on the perception or annoyance of noise. As such, vibration levels due to the proposed project would be insufficient to cause any change in the perception or annoyance of the noise generated as part of the proposed project. In short, given the low vibration related to DM&E's proposed

[15] Öhrström, E. 1997. *Journal of Sound and Vibration* (1997). 205(4), 555-560. Effects of Exposure to Railway Noise—A Comparison Between Areas With and Without Vibration.

[16] Final EIS, Appendix M, pages M-27 to M-36.

[17] Wiss, J. F. (1981), in *Proceedings of the American Society of Civil Engineers, Journal of the Geotechnical Engineering Division*, reports that vibration levels of 0.01 inch/s (1.0 mm/s) or lower would be imperceptible to humans.

operation of coal trains, project-related noise levels would not be perceived by noise sensitive receptors as higher or more annoying than the levels projected for noise alone.

Accordingly, SEA concludes that, while noise and vibration may exhibit synergistic effects in certain circumstances, there is no evidence to support the conclusion that the imperceptible levels of vibration expected to result from the proposed project (1.02 mm/s or 0.04 in/s) would result in any increased annoyance or perception of noise over that of the noise itself in this case. Therefore SEA has determined that noise sensitive receptors would perceive no difference in noise levels over the levels SEA projected in the EIS and SEA is therefore not recommending additional mitigation to address noise/vibration related impacts. SEA stands by its EIS noise and vibration analysis as appropriate and reflective of the potential noise impacts from the proposed project. SEA believes this conclusion is reasonable due to the fact that the vibration resulting from this project would be imperceptible to noise sensitive receptors.

3.5 CONCLUSIONS

SEA previously concluded in the Final EIS that the proposed project would have potentially significant impacts to noise sensitive receptors due to increases in noise from greater numbers of passing trains and locomotive horn soundings. Additionally, SEA concluded that the proposed project would not have significant effects on noise sensitive receptors due to increased vibration as projected vibration levels would be insufficient to cause damage to nearby structures. Following its additional investigation and analysis, SEA finds no evidence to conclude that, at the levels of vibration anticipated from the proposed project, any increase in the annoyance from or perception of noise would occur. As such, SEA finds no reason to modify its prior noise and vibration conclusions, or include mitigation measures beyond those previously recommended and imposed to address these issues.